CLE probe may be tracked using a tracking device and navigation system within a common coordinate system of the registered images.

[0063] At step **810**, the microscopic imaging data are classified. For example, the microscopic imaging data may be classified as, e.g., healthy or tumorous tissue, a particular grade of tumor, a particular type of tumor. FIG. **10** shows a method **810** for classifying microscopic imaging data, in accordance with one or more embodiments.

[0064] At step **1002**, images of the microscopic imaging data are excluded from classification based on an entropy of the images. For example, microscopic imaging data having an entropy less than a threshold value may be excluded from classification as having low image texture information.

[0065] At step **1004**, local image features are extracted from the remaining microscopic imaging data. The local image features may include SIFT descriptors or any other suitable local image features, such as, e.g., LBP, HOG, or any other local image feature or combination of local image features. The local image features may be sampled at every n_s pixels of a region of interest, n_s is any positive integer.

[0066] At step **1006**, the extracted local image features are sorted in a trained vocabulary tree. The trained vocabulary tree may be a binary vocabulary tree learned using hierarchical k-means cluster (k=2). Each extracted local image feature (i.e., feature vector) is passed down the trained vocabulary tree level by level by comparing the respective feature vector with two cluster centers and choosing a closest cluster center to that respective feature vector. The trained vocabulary tree may be learned in an offline training step using training data.

[0067] At step **1008**, a vocabulary histogram is computed as a global image feature for each image of the remaining microscopic imaging data based on the extracted local image features sorted in the trained vocabulary tree. A number of SIFT descriptors located in the leaf nodes of the trained vocabulary tree is determined for each respective image of the remaining microscopic imaging data to compute the vocabulary histogram. The vocabulary histogram may be based on an average pooling function or a max pooling function.

[0068] At step **1010**, the tissue of the patient in the remaining microscopic imaging data is classified based on the vocabulary histogram. The tissue of the patient may be classified as, e.g., healthy or tumorous, a particular grade of tumor, a particular type of tumor, etc. A trained classifier, such as, e.g., SVM, random forest, K-nearest neighbor, or any other suitable classifier may be applied to classify the tissue according to grade of tumor, healthy tissue, etc.

[0069] Returning to FIG. **8**, at step **812**, the classification is displayed. For example, the classification may be displayed as color coded overlays over the registered pre-operative imaging data and/or intra-operative imaging data and/or the microscopic imaging data. The registered pre-operative imaging data and intra-operative imaging data, as well as the microscopic imaging data, may be displayed in a side-by-side configuration, an overlaid configuration, or any other configuration. A location of a probe used to acquire the microscopic imaging data may also be displayed in the registered pre-operative imaging data and intra-operative imaging data.

[0070] FIG. **11** shows a high-level workflow **1100** for a tumor resection procedure of the brain, in accordance with one or more embodiments. In step **1102**, pre-operative images of tissue of a brain of a patient are acquired. The pre-operative images may be annotated or marked with planning information. The tissue may include a tumor. At step **1104**, intra-operative images of the tissue of the brain of the patient are acquired after a craniotomy. The craniotomy causes a deformation in the tissue of the brain due to the change in pressure. At step **1106**, the pre-operative images and intra-operative images are registered, e.g., using a biomechanical model with personalized biomechanical parameters. At step **1108**, the registered pre-operative images and intra-operative images are displayed using a display device. The registered pre-operative images and intra-operative images may be displayed in a side-by-side configuration, an overlaid configuration, or any other configuration.

[0071] At step **1110**, a CLE probe is navigated to the tissue using guidance from the display device. The location of the CLE probe may be displayed with the registered pre-operative images and intra-operative images using a tracking device instrumented on the CLE probe. At step **1112**, microscopic images are acquired from the CLE probe of at a border of the tumor on the tissue. At step **1114**, a classification of the tissue is determined in the microscopic images as at least one of tumorous tissue (or a type/grade of tumorous tissue) and healthy tissue. At step **1116**, a color representing the classification of the tissue is displayed as being overlaid on the registered pre-operative images and intra-operative images. For example, a red overlay may indicate tumorous tissue while a green overlay may represent healthy tissue. At step **1118**, the tumor is resected. At step **1120**, the classification is updated and displayed. If the display only shows healthy tissue, the procedure ends at step **1122**. However, if the display shows tumorous tissue, workflow **1100** returns to step **1118** and the tumorous tissue is again resected.

[0072] Systems, apparatuses, and methods described herein may be implemented using digital circuitry, or using one or more computers using well-known computer processors, memory units, storage devices, computer software, and other components. Typically, a computer includes a processor for executing instructions and one or more memories for storing instructions and data. A computer may also include, or be coupled to, one or more mass storage devices, such as one or more magnetic disks, internal hard disks and removable disks, magneto-optical disks, optical disks, etc.

[0073] Systems, apparatus, and methods described herein may be implemented using computers operating in a client-server relationship. Typically, in such a system, the client computers are located remotely from the server computer and interact via a network. The client-server relationship may be defined and controlled by computer programs running on the respective client and server computers.

[0074] Systems, apparatus, and methods described herein may be implemented within a network-based cloud computing system. In such a network-based cloud computing system, a server or another processor that is connected to a network communicates with one or more client computers via a network. A client computer may communicate with the server via a network browser application residing and operating on the client computer, for example. A client computer may store data on the server and access the data via the network. A client computer may transmit requests for data, or requests for online services, to the server via the network. The server may perform requested services and provide data